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Theoretical Investigation of Liquid Water Injection Into the Shock Layer of a Reentry Vehicle

Progress Report No. 1

for the period September 1, 1965 to February 28, 1966

Prepared by

H. A. Hassan

Project Director

Department of Mechanical Engineering

North Carolina State University

Raleigh, North Carolina

The work done in the period September 1, 1965 to February 28, 1966 can be summarized as follows:

1. Derivation of the governing equations from statistical considerations as outlined by Williams (Reference 1).

2. Investigation of the possible forms of the evaporation and heat transfer rates to a droplet.

3. Investigation of the numerical technique that can be used to solve the governing equations.

The first phase was motivated by the desire of having an accurate set of the governing equations. The resulting set of equations was similar to those outlined in the proposal except for a term representing the momentum of the evaporating particles in the momentum equations and a term representting the work of the drag free on the particles in the energy equations.

Next, a thorough investigation was made of the available evaporation rates and heat flux rates to droplets. As a result of the evaporation, the effective radius of a droplet decreases from values which are in general larger than a mean free path to values which are much less than a mean free path. Thus, expressions describing heat transfer and evaporation rates should be derived which give the appropriate limits in the continuum and free molecule regimes. Suitable expressions which converge to the proper limits have been derived.

Because of the complexity of the governing equations, it was decided to obtain a solution by using the method of integral relations. As a first step in utilizing this method, the governing equations have to be written in

divergence form. Since there is no unique way of writing these equations in divergence form, one encounters the same problems encountered earlier with blunt body solutions (Reference 2). Because of this, and because there are no "exact" solutions or experimental results available at present, solutions will be obtained for various formulations of the equations (Reference 2). Other numerical schemes are also being considered.

It is expected that numerical calculations will start toward the end of this month.

References

1. Williams, F. A., Combustion Theory, Chapter 11.

2. Xerikos, J. and Anderson, W. A., AIAA J., Vol. 3, No. 3, pp. 451-457, 1965.